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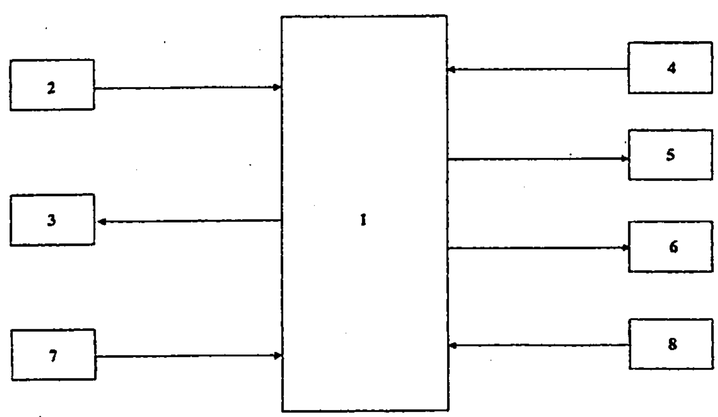
(54) Title: LINE VOLTAGE ADAPTIVE REFRIGERATOR



(57) Abstract: The total compressor running time after defrost t_n is calculated by adding the value obtained by multiplying the difference between the optimum defrost time t_{defopt} determined by the experiments and the actual defrost time $t_{def(n)}$ with a constant value K determined by the manufacturer to the total compressor running time before defrost t_{n-1} without checking the line voltage first. The total compressor running time t_{yn} adaptive to the line voltage is calculated by multiplying the difference between the square of the average line voltage value found by monitoring the line voltage during the defrost time by the line voltage measuring unit (8), and the average line voltage value measured during the previous defrost cycle, by a constant L value determined by the manufacturer and by adding this value to the above mentionned total compressor running period after defrost t_n, that is calculated without regarding the line voltage.

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LINE VOLTAGE ADAPTIVE REFRIGERATOR

The present invention relates to performing the defrosting process in refrigerators in accordance with the changes in the line voltage.

Cooling in the refrigerators is provided by a heat exchange between the environment and the evaporator through which a fluid with a high heat transfer rate is passed. During the said heat exchange between the environment and the evaporator, a frost load is formed on the evaporator.

This frost load accumulated on the evaporator is not desired as it reduces the heat transfer between the environment and the evaporator and thus leads to a lower cooling efficiency.

In order to avoid the above mentioned inconveniences, a defrosting operation is realized in the refrigerators.

The frost load formed on the evaporator is avoided by blowing warm air on the evaporator or by placing a heater on the evaporator or by a similar method.

The defrosting periods in the refrigerators should be adjusted dynamically according to the user habits, environmental conditions and the input values given to the system. Adaptive defrosting is a known method.

The adaptive defrosting process determines the necessary duration of the next defrosting cycle by comparing the realized defrosting cycle duration and the optimal defrosting cycle duration determined as the result of the experiments.

If the realized defrosting cycle is longer than the optimum period determined as the result of the experiments, it shows that an excessive amount of frost has accumulated on the evaporator and the necessary total compressor

running period that will pass till the start of the next defrosting cycle is determined to be shorter than the previously determined defrosting period.

If the realized defrosting cycle is shorter than the optimum period determined as the result of the experiments, it shows that a small amount of frost has accumulated on the evaporator and the necessary total compressor running period that will pass till the start of the next defrosting cycle is determined to be longer than the previously determined defrosting period. Thus, the adaptive defrosting cycle makes the duration of defrosting cycle equal to the optimum duration. However the changes occurring in the line voltage causes some problems in the performance of the defrosting process.

In cases where the line voltage is lower than the normal line voltage, the defrosting duration is longer and the adaptive defrosting process decides that an excessive amount of frost has accumulated on the evaporator and defines the necessary total compressor running period that will pass till the start of the next defrosting cycle to be shorter, thereby defrosting cycle starts before an expected amount of frost has accumulated on the evaporator, thus causes unnecessary energy consumption. Furthermore, in cases where the line voltage is higher than the normal line voltage, the defrosting duration is shorter and the adaptive defrosting process decides that a small amount of frost has accumulated on the evaporator and defines the necessary total compressor running period that will pass till the start of the next defrosting cycle to be longer, which in turn causes the start of defrost after an amount of frost that is much more than the expected amount, has accumulated on the evaporator and this has a negative impact on the performance of the refrigerator.

In prior art, the principle where the current over the fan motor placed in the refrigerator is proportional to the amount of the frost load accumulated on the evaporator is used. By comparing the said current with a predetermined constant current value, a decision for defrosting is taken. One deficiency of this method is

the fact that the defrosting duration is also dependent on the ambient temperature. Another deficiency is the fact that the system is influenced by the changes in the voltage applied on the fan motor.

Also, even a small particle in the air flow can change the current passing over the fan motor and any deformation that may occur in the fan anti-friction bearings may cause a rush of current, thus leading to an early defrost decision.

In the US Patent No. 4400949, in addition to the value of the current passing over the fan motor, the voltage value between the two ends of the fan motors as well as the temperature values in the cooling compartment, have been measured and a relationship has been obtained by using the temperature, current and voltage values taken at the moment when defrosting has been completed, and this equation has been used in the step of decision for defrosting. The difference between the ambient temperature and the temperature over the evaporator tubes is observed as well to understand whether or not this difference has exceeded a predetermined value. When both requirements are met, it is decided to start the defrosting process.

In the adaptive defrost methods, the fluctuations in the line voltage during the day, create an important problem.

The object of the present invention is to realize the defrosting process in accordance with the line voltage in order to provide a reduction in the energy consumption and an improvement in the cooling performance of the refrigerator.

The adaptive defrost technique in accordance with the line voltage, realised in order to attain the above mentioned object of the invention is illustrated in the attached drawings, wherein;

Figure 1, is the control block diagram,

Figure 2, is the general view of the refrigerator.

The components shown in the drawings have the following numbers;

1. Control unit
2. Direct current (DC) power supply unit
3. Driver unit
4. Display unit
5. Input unit
6. Function selecting unit
7. Temperature sensing unit
8. Line voltage measuring unit.

The control unit (1) comprises the electronic memory elements, a micro processor and an A/D converter to process the input data. The control unit (1) controls the refrigerator according to a preloaded program in its microprocessor.

The DC power supply unit (2) converts the source voltage obtained from the AC power supply to the DC voltage level that is required by the refrigerator control unit (1), driver unit (3), display unit (4), input unit (5), function selecting unit (6), temperature sensing unit (7) and the line voltage measuring unit (8).

The display unit (4) shows the actual temperature values in the freezer and cooling compartments of the refrigerator.

The function selecting unit (6) allows the user to make the temperature settings for the freezer and cooling compartments, and to choose the specific functions (e.g. quick frost, holiday, etc.). When the user adjusts the temperature value in each compartment using this unit, the said temperature values are sent to the control unit (1).

The temperature sensing unit (7) comprises the temperature sensors in the freezer and cooling compartments.

The driver unit (3) controls the compressor and the defrost heater, in line with the signals sent from the control unit (1).

The input unit (5) detects whether the freezer or cooling compartment doors are open or closed.

The line voltage measuring unit (8) continuously measures the line voltage and transfers the data to the control unit (1).

During adaptive defrosting process, the total compressor running time after defrost t_n is calculated by adding the value obtained by multiplying the difference between the optimum defrost time t_{defopt} determined by experiments and the actual defrost time $t_{def(n)}$ with a constant value K determined by the manufacturer, to the total compressor running time before defrost t_{n-1} without checking the line voltage first.

$$t_n = t_{n-1} + (t_{defopt} - t_{def(n)}).K$$

Wherein;

t_n is the total compressor running time planned after defrost.

t_{n-1} is the total compressor running time realized before defrost.

t_{defopt} is the optimum defrost time.

$t_{def(n)}$ is the actual defrost time.

K is the constant value.

By monitoring the line voltage during the defrost time using the line voltage measuring unit (8), the average line voltage value is found.

The total compressor running time which will be adaptive to the line voltage t_{yn} is calculated by adding the value obtained by multiplying the difference between the square of the average line voltage value found by monitoring the line voltage during the defrost time using the line voltage measuring unit (8), and the square of the average line voltage value measured during the previous defrost cycle, with a constant value L determined by the manufacturer, to the above mentioned total compressor running time after defrost t_n, that is calculated without regarding the line voltage.

$$t_{yn} = t_n + [(V_n)^2 - (V_{n-1})^2].L$$

Wherein :

t_{yn} is the compressor running time adaptive to the line voltage.

t_n is the compressor running time planned after defrost.

V_n is the average line voltage measured during defrost.

V_{n-1} is the average line voltage measured during the previous defrost cycle.

L is the constant value.

By this way, the deviations in the total compressor running times that occurred as the result of the changes in the line voltage have been minimized and the unnecessary energy and performance losses in the refrigerator have been avoided.

CLAIMS

1. A refrigerator comprising a control unit (1), a driver unit (3) that controls the compressor and the defrost heater, a display unit (4) that shows the actual temperature values in the freezer and cooling compartments of the refrigerator, an input unit (5) that detects whether the freezer or cooling compartment doors are open or closed, a function selecting unit (6) that allows the user to make the temperature settings for the freezer and cooling compartments, and to choose the specific functions (e.g. quick frost, holiday, etc), a temperature sensing unit (7) that comprises the temperature sensors in the freezer and cooling compartments, a line voltage measuring unit (8) that measures the line voltage, a DC power supply unit (2) that converts the source voltage obtained from the AC power supply to the DC voltage level that is required by the control unit (1), the driver unit (3), the display unit (4), the input unit (5), the function selecting unit (6), the temperature sensing unit (7), the line voltage measuring unit (8) of the refrigerator, wherein the control unit (1) calculates the total compressor running time t_{yn} that is adaptive to the line voltage by multiplying the difference between the square of the average line voltage value found by monitoring the line voltage during the defrost time and the square of the average line voltage value measured during the previous defrost cycle, with a constant value L determined by the manufacturer and by adding this value to the total compressor running period after defrost t_n, that is calculated without regarding the line voltage, by adding the value obtained after the multiplication of the difference between the optimum defrost time t_{defopt} determined by experiments and the actual defrost time $t_{def(n)}$ by a constant value K determined by the manufacturer, to the total compressor running time before defrost t_{n-1} when the line voltage during the defrost cycle is lower or higher than the normal level, and the line voltage measuring unit (8) measures the line voltage and transfers these values to the control unit (1) concurrently.

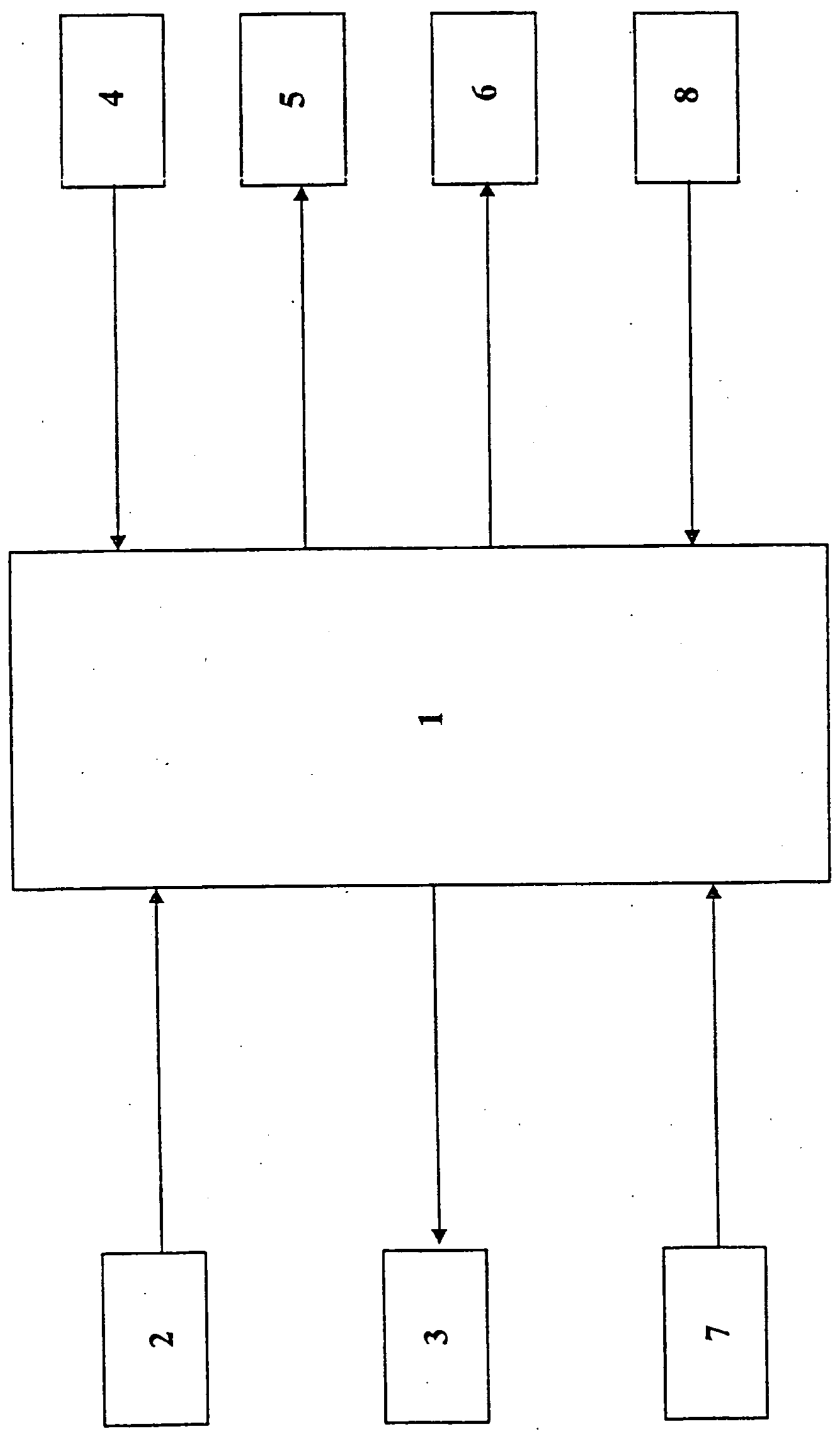
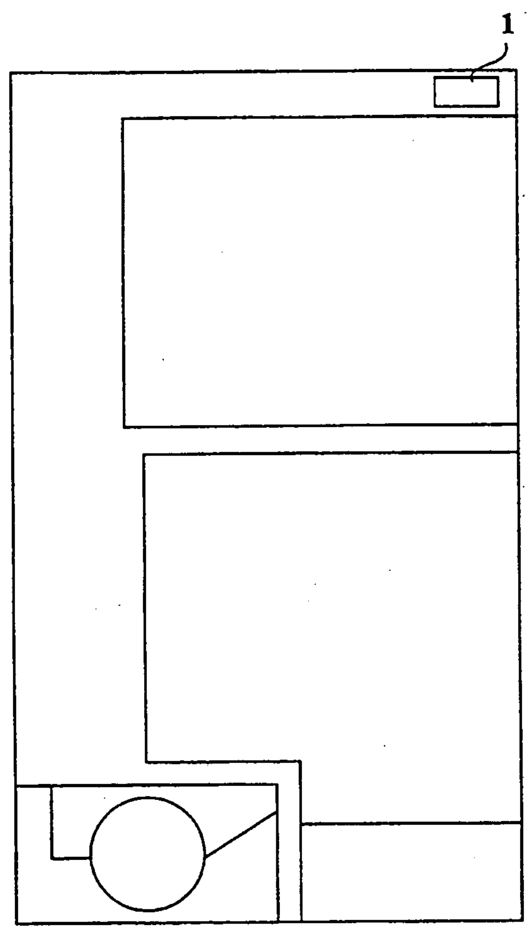


Figure 1

Figure 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR 00/00038

CLASSIFICATION OF SUBJECT MATTER

IPC[7]: F25D 21/00; F 25B 49/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7]: F25D, F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5765382 A (MANNING) 16 June 1998 (16.06.98) totality.	1
A	US 5415005 A (STERBER) 16 May 1995 (16.05.95) totality.	1
A	US 5237830 A (GRANT) 24 August 1993 (24.08.93) totality.	1
A	US 4653285 A (POHL) 31 March 1987 (31.03.87) totality.	1
A	US 4400949 (KINOSHITA) 30 August 1983 (30.08.83) totality.	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
„A" document defining the general state of the art which is not considered to be of particular relevance
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„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Patent document cited in search report			Publication date	Patent family member(s)			Publication date
US	A	4400949	30-08-1983	JP	A2	57144862	07-09-1982
				JP	B4	60008431	02-03-1985
				KR	B1	8700881	30-04-1987
US	A	4653285	31-03-1987	US	A	4724678	16-02-1988
US	A	5237830	24-08-1993			none	
US	A	5415005	16-05-1995	AU	A1	13377/95	27-06-1995
				CA	AA	2178647	15-06-1995
				WO	A1	9516172	15-06-1995
				US	A	5515692	14-05-1996
US	A	5765382	16-06-1998			none	